

**GRAIN SORGHUM PRODUCTION**  
**as an Alternative Land Use**  
**ON MOLOKAI**

Peter V. Garrod

College of Tropical Agriculture  
Hawaii Agricultural Experiment Station  
University of Hawaii  
Departmental Paper 7—March 1973—2.5M



## CONTENTS

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Basic Assumptions Incorporated in the Analysis.....	3
Scale of Operation.....	3
Land.....	4
Cropping System.....	4
Planting Dates.....	4
Irrigation.....	4
The General Resource Requirements.....	6
Feasibility.....	7
Analysis.....	7
Feasibility.....	12
Conclusions from Sorghum Feasibility Study.....	14

## THE AUTHOR

Peter V. Garrod is Assistant Agricultural Economist, Hawaii Agricultural Experiment Station, and Assistant Professor of Agricultural and Resource Economics, College of Tropical Agriculture, University of Hawaii.

# SORGHUM PRODUCTION ON THE ISLAND OF MOLOKAI:

## A FEASIBILITY STUDY

Peter V. Garrod

Currently, grain sorghum looms large as an alternate crop for lands that will be going out of pineapple production on the Island of Molokai. This paper will outline some of the factors affecting the economic and physical feasibility of producing sorghum on Molokai.

Plucknett et al. in a recent bulletin<sup>1/</sup> indicate that sorghum is well adapted to Hawaii's agronomic conditions, limited by the lack of established market outlets and handling facilities, grain drying conditions, and disease and pest problems.

Drew<sup>2/</sup> has published preliminary analyses on the economic feasibility of grain sorghum production in Hawaii. Based on general operating requirements in terms of equipment and cultural requirements, Drew has determined the minimum per acre yields necessary for sorghum production to be economically feasible under varying product-market conditions. Drew also outlines some of the potential markets for sorghum and analyzes what trends to expect in future demands for sorghum.

The presentation that follows uses without restriction the budget of estimated costs of sorghum production prepared by Drew, changing only those factors which the distinct conditions on Molokai necessitate.

### Basic Assumptions Incorporated in the Analysis

The analysis contained in this paper was based on the following assumptions:

Scale of Operation. The budgetary analysis of Drew was based on the operation of a 3000-acre farm. The greatest economies of scale are assumed to exist in the milling and distribution systems. Therefore, it is not expected to find significant differences in the per acre costs of producing sorghum for farms of smaller scale such as 1000 acres. For operations smaller than 1000 acres, however, the per acre cost of producing sorghum will increase substantially.

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<sup>1/</sup> Plucknett, D. L., O. R. Younge, T. Izuno, Y. N. Tamimi, and S. M. Ishizaki. Sorghum Production in Hawaii, Research Bulletin 143, Hawaii Agricultural Experiment Station, University of Hawaii, September 1971.

<sup>2/</sup> Drew, D. C. Economic Feasibility of Grain Sorghum Production in Hawaii, Research Report 209, Hawaii Agricultural Experiment Station, University of Hawaii, May 1972.

Land. The land resource available for sorghum production on Molokai is assumed to be in the Hoolehua and Mauna Loa regions. This land is potentially highly productive if the necessary water for irrigation is made available. <sup>3/</sup> The soils are deep, well drained, clay loams, well suited to machine tillage.

Elevation of these lands is between 600 and 1000 feet, with an average annual rainfall of 20 to 35 inches and mean temperatures between 60 F and 78 F. Minimum temperatures below 60 F regularly occur during the months of December, January, and February.

Cropping System. Production of sorghum in this analysis is for sale as grain. The cropping year consists of a plant crop that takes 105 days to mature followed by two ratoon crops each taking 90 days to mature. Following the first two harvests, the forage is cut to a height of 6 inches and fertilizer is applied to the ratoons.

Another cropping system is also considered. This is a single harvest system without a ratoon crop. Such a crop is projected to take 100 days to reach maturity.

Planting Dates. The high probabilities of having temperatures of less than 60 F during the months of December, January, and February limits the possible planting times for sorghum on Molokai. Temperatures of less than 60 F occurring during the flowering stage of plant development are known to cause sterility in sorghum.

The planting dates used in formulating this analysis were February 15 for a plant crop and two ratoon crop system and April 1 for a single harvest system.

April was chosen for the crop system to utilize the increases in solar radiation occurring later in the year and the water stored in the ground from the winter rain. Sorghum yields are generally believed to be positively related to the rate of solar radiation during the growing period.

Irrigation. Although sorghum is remarkably well adapted to environments with some limitation in available moisture, it is also an efficient user of water, becoming highly productive under conditions with ample available moisture. Recent studies in Texas defined the yield response curve for water illustrated in Figure 1.

In this study, it is assumed that 20 inches of effective moisture is necessary for the plant crop and 16 inches of water is necessary for each of the ratoons. Table 1 illustrates the estimated schedule and quantities of water

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<sup>3/</sup> Land Study Bureau. Detailed Land Classification - Island of Molokai, Land Study Bureau Bulletin No. 10, LSB, University of Hawaii, June 1968.

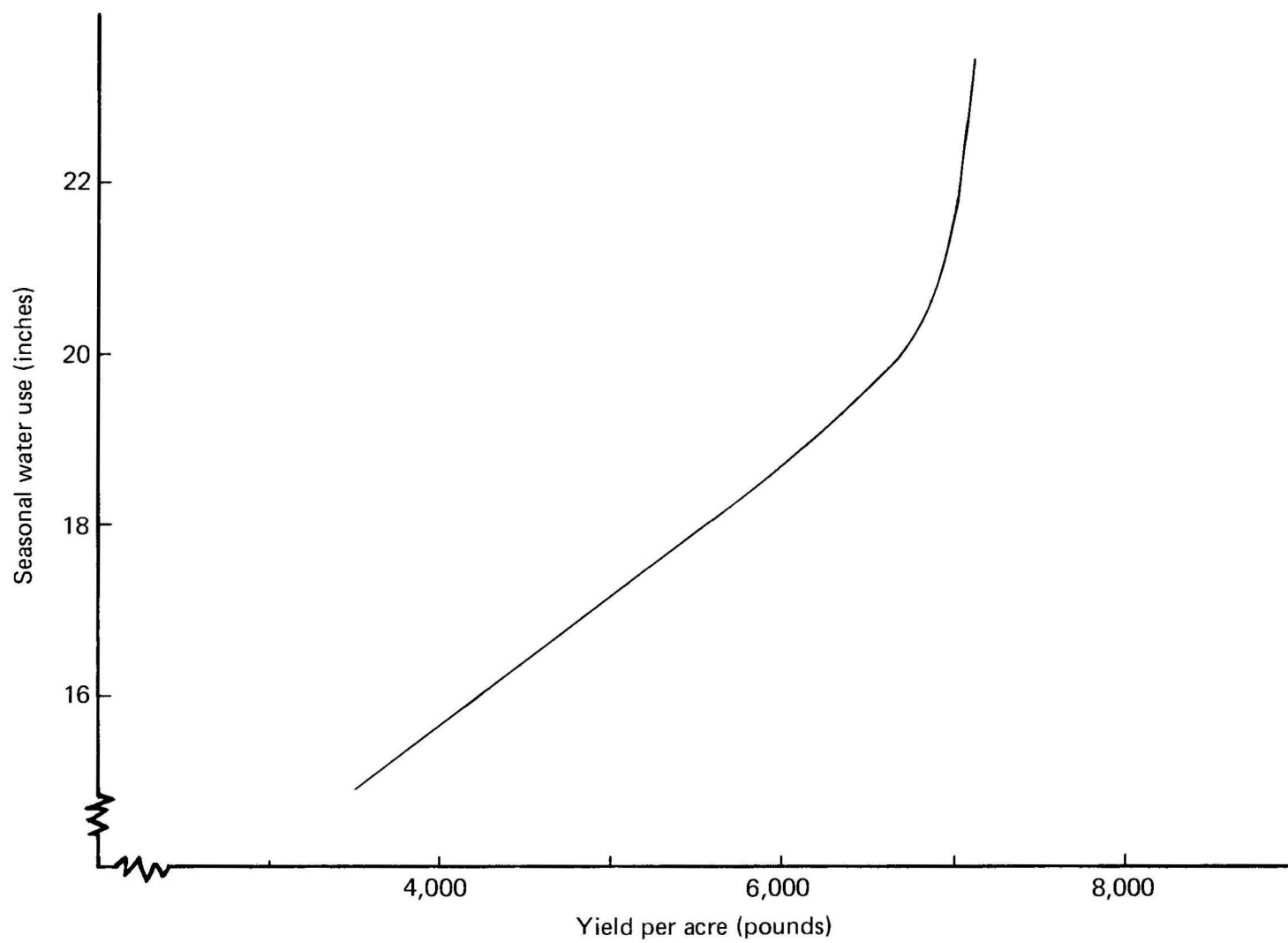


Figure 1. Water response curve for sorghum (single crop).

Source: Musick, J. T., and W. H. Sletten, "Grain Sorghum Irrigation—Water Management of Richfield and Pullman Soils," Transactions of the American Society of Agricultural Engineers, vol. 9, 1966, p. 369–373.

applied for sorghum production on Molokai. Here it is assumed that rainfall will provide enough moisture for adequate plant development up to the 6- to 8-leaf stage of the plant crop. From this point until late fall it is assumed that all moisture required by the plants for adequate growth will have to be applied through irrigation. Inherent in these assumptions is the supposition that monthly rainfall of less than 2 inches is ineffective with regards to sorghum plant growth, given the temperature, humidity, and wind conditions existing on Molokai. The plant crop will require that 14 inches of water be applied and the first ratoon will require 16 inches. The second ratoon, however, is expected to receive some effective moisture from rainfall occurring in the late fall and therefore will only require 14 inches of water from irrigation.

In formulating Table 1, it was assumed that the moisture requirements for the plant crop are equal, regardless of which planting date is used.

Table 1. Irrigation requirements: timing and quantity

Timing	Plant crop	First ratoon	Second ratoon
Initial or preplanting	--	4	4
6- to 8-leaf stage	2	--	--
Mid to late boot	4	4	4
Heading and flowering	4	4	4
Milk to soft dough	4	4	2
Total	14	16	14

#### The General Resource Requirements

The general resource requirements used in this analysis are identical to those developed by Drew <sup>4/</sup> with the following exceptions. Stone picking was assumed not to be a required practice on Molokai and this operation was excluded from the budget analysis. Irrigation activities were assumed to be twice as expensive on Molokai as compared to Drew's figures (slightly more than five times the quantity of water will be applied).

<sup>4/</sup> Op. cit.



The necessary materials, supplies, and associated costs are also drawn directly from Drew's study, the only exception being the quantity and cost of water. In the following analysis, the cost of water is treated as a variable rather than a fixed budget item.

The per acre cost of fixed plant and vehicles is drawn directly from Drew's work without modification.

An operation consisting of 1000 acres would employ approximately 10 persons, including all administrative personnel.

Overhead costs are also drawn directly from Drew's work, the only change being that here the cost of land is treated as a variable rather than a parameter.

Table 2 presents a breakdown of the direct per acre costs associated with the plant crop and Table 3 presents the average direct per acre costs associated with ratoons. Table 4 presents a summary of total costs per acre of producing sorghum. Figures 2 and 3 present the break-even price ratio under different assumptions regarding water and land costs.

#### Feasibility

The break-even price ratio is the market price of sorghum (f.o.b. Molokai) necessary for the producer to cover costs, given the per acre yield. The following figures graphically illustrate the necessary relations between price and per acre yield necessary to cover costs.

Analysis. After examining Tables 5 and 6 and Figures 2 and 3, it is immediately clear that a rational farmer would produce one plant crop followed by two ratoons. For any market price situation and for land and water prices used in Tables 5 and 6, the critical yield to cover cost in the plant and two ratoon case is only twice the critical yield for the same market situation considering only the plant crop. This is due to the fact that the plant and two ratoon system spreads the fixed costs over three harvests rather than one harvest as is the case with a single (plant) crop. Normally, we would expect the yield of each ratoon to be similar to the yield of the plant crop.

If a market price for grain sorghum of 3.8 cents a pound is considered,<sup>5/</sup> the four estimates of possible production costs used in Figure 6 would necessitate minimum production levels of 12,100, 14,200, 16,300, and 18,400 pounds per acre per year to cover costs. (Per acre yields between 11,000 and 17,000 pounds can be considerably reasonable under Hawaiian conditions for a plant crop and two ratoons.) Any production in excess of these levels would define a profitable situation and yields below would indicate losses. Graphically, for a given cost situation, any point as defined by current market and yield conditions that lies above the curve representing the appropriate cost situation defines a profitable situation for the production of grain sorghum.

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<sup>5/</sup> Approximate price for Hawaii-produced grain sorghum, November 1972.

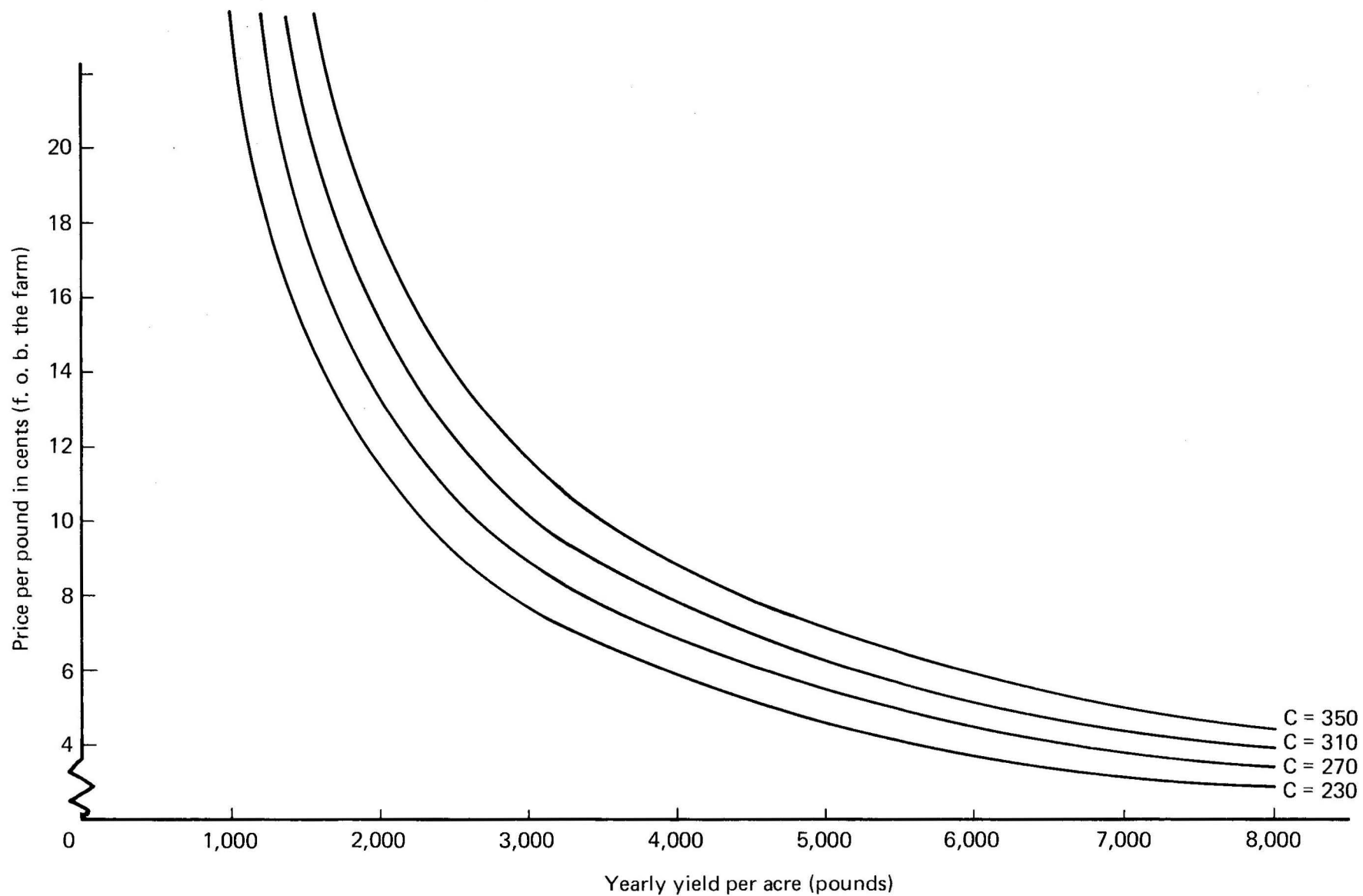


Figure 2. Break-even price and yield combinations for plant crop only, using four possible per acre harvest costs (C).



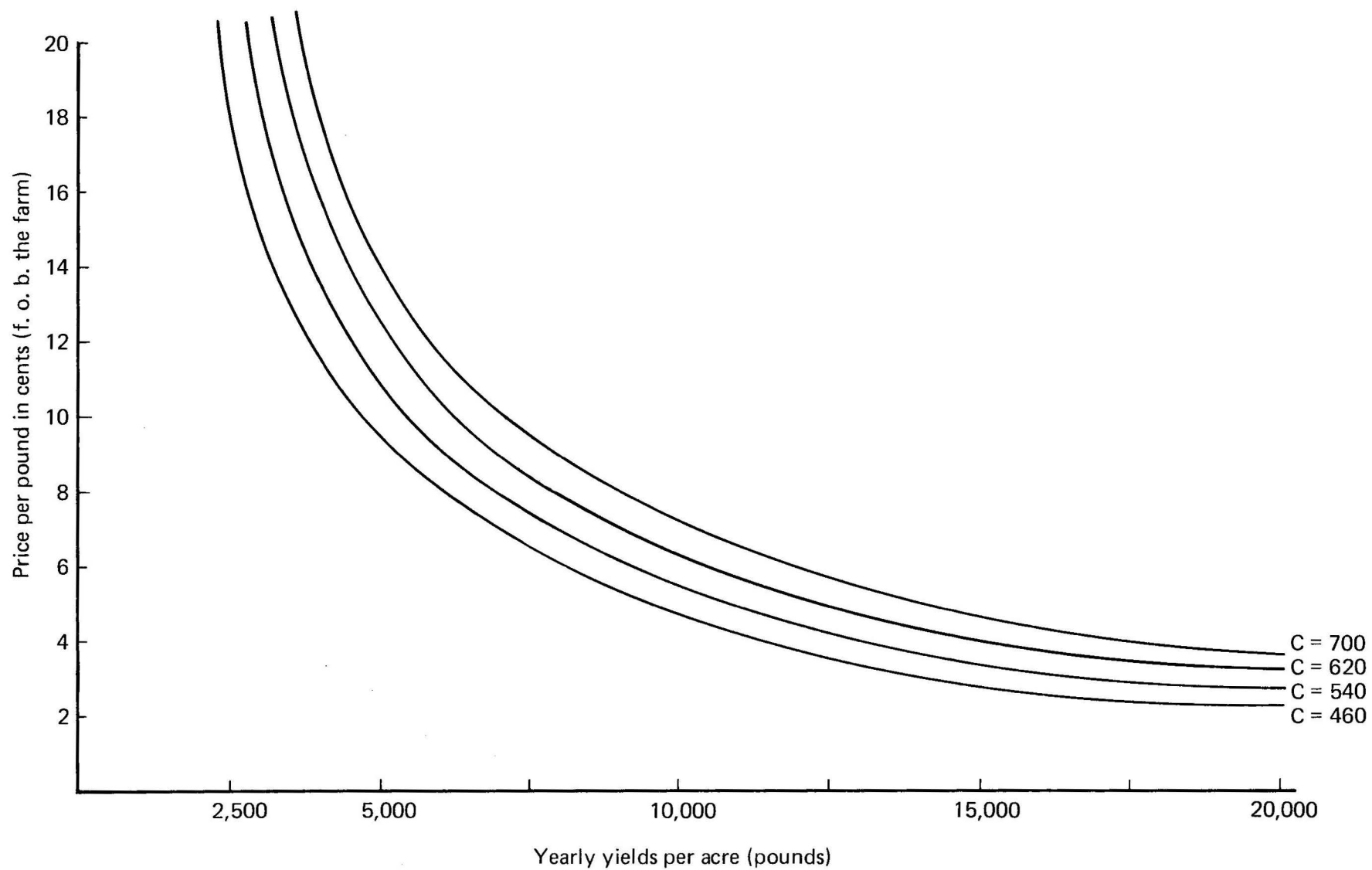


Figure 3. Break-even price and yield combinations for plant crop and two ratoons for four possible per acre harvest costs (C).

Table 2. Per acre direct costs for irrigated sorghum production on Molokai (plant crop)\*

Costs	Dollars/acre
Machinery and implements	37.33
Labor	45.10
Materials and supplies	72.48
Water	380.2 Pw <sup>a/</sup>
Total direct costs	154.91 + 380.2 Pw

\* For detailed breakdown of costs, see Drew, op. cit., Table 2, p. 6-7.

a/ Pw = cost of water per 1000 gallons (f.o.b. the farm)

$$380.2 = \frac{14 \text{ acre-inches} \times 27,156 \text{ gal/acre-inch}}{1000}$$

Table 3. Per acre direct costs for grain sorghum production on Molokai (average for two ratoons)\*

Costs	Dollars/acre
Machinery and implements	24.86
Labor	36.10
Materials and supplies	81.06
Water	407.3 Pw <sup>a/</sup>
Total direct costs	142.02 + 407.3 Pw

\* For detailed breakdown of direct costs, see Drew, op. cit., Table 3, p. 8-9.

a/ Pw = cost of water per 1000 gallons (f.o.b. the farm)

$$407.3 = \frac{15 \text{ acre-inches} \times 27,156 \text{ gal/acre-inch}}{1000}$$

Table 4. Summary of annual grain sorghum  
production costs per acre

Item	Plant crop only	Plant crop with two ratoons
	Dollars/acre	Dollars/acre
Direct costs		
Plant crop	154.91	154.91
Two ratoons		184.04
Water costs	380.2 $P_w^a$	1,194.8 $P_w^a$
Costs of fixed plant and vehicles	21.99	21.99
Overhead costs	18.33	18.33
Land costs	$\frac{b}{A}$	$\frac{b}{A}$
Total per acre costs	195.23 + 380.2 $P_w$ + A	379.27 + 1,194.8 $P_w$ + A

a/ Cost of water per 1000 gallons (f.o.b. the farm).

b/ Per acre land rental costs.

Table 5. Total costs per acre for a single harvest system

Water prices ( $P_w$ ) $\frac{a}{}$	Land rents (A)			
	\$20/acre	\$40/acre	\$60/acre	\$80/acre
	Dollars	Dollars	Dollars	Dollars
.05	234.24	254.24	274.24	294.24
.10	253.25	273.25	293.25	313.25
.15	272.26	297.26	312.26	332.26
.20	291.27	311.27	331.27	351.27

a/ Cost of water per 1000 gallons (f.o.b. the farm).

Table 6. Total costs per acre for a plant crop and two ratoon system

Water prices (Pw) <u>a/</u>	Land rents (A)			
	\$20/acre	\$40/acre	\$60/acre	\$80/acre
	Dollars	Dollars	Dollars	Dollars
.05	459.01	479.01	499.01	519.01
.10	518.48	538.48	558.48	578.48
.15	577.95	597.95	617.95	637.95
.20	637.42	657.42	677.42	697.42

a/ Cost of water per 1000 gallons (f.o.b. the farm).

Sorghum production of Molokai would require that 44 acre-inches of water, or 1.19 million gallons of water, be applied to each acre used in sorghum production during the crop year. Currently, the Molokai Water Project is providing approximately an average of 4.1 million gallons a day, or a total of 1.5 billion gallons of water per year. If all this water were made available to irrigate sorghum, it would be possible to irrigate a total of 1300 acres of sorghum. Obviously, all of this water cannot be diverted to sorghum. Also, given the temperature and wind conditions on Molokai, evaporation will account for a significant quantity of water. If we assume that half the total available water will be made available for sorghum irrigation purposes, this would be sufficient to irrigate 650 acres.

Feasibility. The previous analysis of the per acre cost was based on a ranch of 3000 acres. It is reasonable to assume that these per acre costs will also be representative of a smaller scale operation, but only down to a certain size. The per acre costs for a ranch of 650 acres are generally significantly more than those of a larger operation of more than 1000 acres. The small scale of the possible sorghum-producing unit on Molokai directly implies that per acre costs will be higher than larger scale operations elsewhere. No information presently available indicates that per acre production or the price of sorghum f.o.b. the farm will be greater on Molokai, implying that the possibility of producing sorghum on Molokai will compare unfavorably with the economic feasibility of producing sorghum elsewhere in Hawaii.

The restraint on sorghum acreage imposed by the supply of water limits the feasibility of sorghum production on Molokai in yet another way. For the production of sorghum to economically become possible, a market infrastructure oriented towards the handling, processing, and marketing of sorghum must either

exist or be created. Grain driers, mills, storage facilities, grain shippers, and the rest of the operations and institutions associated with the marketing of cereals have tremendous economies of scale. A large production base is needed before these operations become economically viable.

The limited quantity of water available alone implies that the production of grain sorghum is not at this time an economically feasible activity on Molokai. Although this analysis was made with regards to grain sorghum production the results should be directly applicable to the production of sorghum for sale in other forms. The diseconomies of scale resulting from the small production base will increase the per acre costs of production and per unit marketing costs enough to effectively limit the feasibility of producing sorghum.

It must be realized, that even if there were ideal weather conditions, good market conditions, and an ample supply of water for irrigation, the feasibility of producing sorghum on Molokai would be severely limited by the cost of water. The actual per unit cost of water (f.o.b. the farm) is not known. The factors that affect water costs for different regions on Molokai will have to be quantified before the costs of producing sorghum, or any other irrigated crop, can be exactly specified.

The water price facing the potential producer on Molokai will be a function of several factors, including the price charged by the Molokai Water Project, hook-up costs, and the cost of delivering the water to the farm. The actual value of these costs is not yet known, but the hook-up costs and the cost of bringing the water to the farm could be quite substantial, especially if pumping is necessary.

The importance of water costs in relation to the total costs of producing sorghum is illustrated by Table 6. If the farm's water costs were 10¢ per thousand gallons, the per acre water bill would be \$119.50, or water costs would represent 23 percent of the total costs of producing sorghum. <sup>6/</sup> If the water price facing the farmer were 20¢ per thousand gallons, the per acre water bill would be \$239.00, or water costs would represent 37 percent of all costs.

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<sup>6/</sup> Here it is assumed that land rent is \$20.00 per acre.

### Conclusions from Sorghum Feasibility Study

This study of the possibilities of producing sorghum on the Island of Molokai indicates that, due to the lack of water available for irrigation, sorghum production is not a feasible economic activity. If all the water presently being delivered by the Molokai Water Project were to be used for irrigation purposes, no more than 1300 acres of sorghum could be produced. The current supply of water makes it impossible to produce enough sorghum either to support the necessary infrastructure or to create an efficient production system.

Lack of available water for irrigation purposes is not the only factor limiting the feasibility of sorghum production on Molokai. For sorghum production to become an economically viable activity, there must not only be adequate water supplies, but there must also be ample water available at a reasonable cost.

The present lack of water and the potential water costs which restrict the feasibility of sorghum production on Molokai will also limit the feasibility of other forms of diversified agriculture that require irrigation. Corn, for example, requires twice as much water as sorghum.





